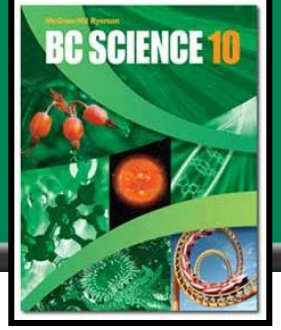
4.3 Balancing Chemical Equations



- **Chemical reactions**
- **Reactants → Products**
  - **A word equation:**
    - **Nitrogen monoxide + oxygen → nitrogen dioxide**
  - **A symbolic equation:**
    - $2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$

Coefficients

- Indicate the ratio of compounds in the reaction.

- Here, there is twice as much NO and NO_2 than as is O_2.

State of matter

- Letters indicate the state of each compound.

(aq) = aqueous/dissolved in water

(s) = solid

(ℓ) = liquid

(g) = gas

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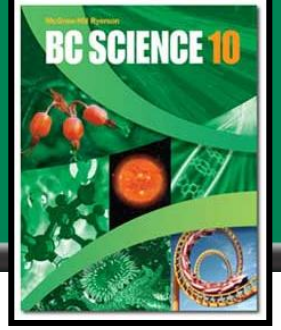
Conservation of Mass in Chemical Change



- **The law of conservation of mass:**
  - **No new matter is created or destroyed; atoms are just rearranged.**
  - **Mass of reactants = mass of products**
  - **Number of each atom in reactants = number of each atom in products.**

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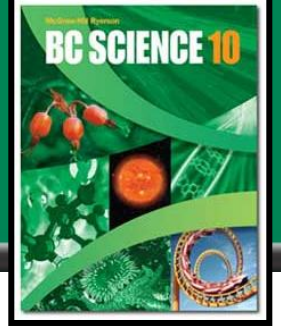
Writing and Balancing Chemical Equations



- **The simplest form of chemical equation is a word equation.**

Arrow means "produces."

Reactants appear on left side of arrow.

potassium metal + oxygen gas → potassium oxide

Products appear on right side of arrow.

Plus sign on left side means "reacts with."

Plus sign on right side means "plus."

  - **A skeleton equation shows formulas of reactants and product, but not quantities of atoms.**
    - $K + O_2 \rightarrow K_2O$
- **Balanced chemical equation**
  - **Balancing ensures that the number of each atom is the same on both sides of the reaction arrow.**
  - **Always use the smallest whole-number ratio**
    - $4K + O_2 \rightarrow 2K_2O$

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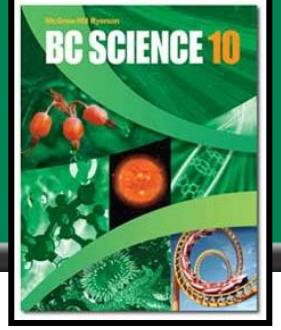
Counting Atoms to Balance an Equation



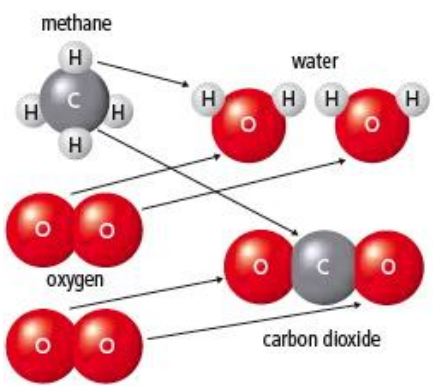
Skeleton equation: $CH_4 + O_2 \rightarrow H_2O + CO_2$

Carbon:	Carbon:
Hydrogen:	Hydrogen:
Oxygen:	Oxygen:

To balance, attempt to find values that equate atoms on both sides

- **Balanced equation:** $CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$

Carbon:	Carbon:
Hydrogen	Hydrogen:
Oxygen:	Oxygen:



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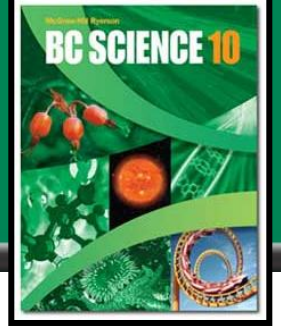
Hints for Writing Word Equations



- **The "special seven" are all diatomic elements**
  - **H_2, O_2, F_2, Br_2, I_2 N_2 Cl_2**

1																	
1 + H Hydrogen 1.0																	18
																	2 0 He Helium 4.0
						14		15		16		17					
						6 C Carbon 12.0		7 3– N Nitrogen 14.0		8 2– O Oxygen 16.0		9 – F Fluorine 19.0					10 0 Ne Neon 20.2
						14 Si Silicon 28.1		15 3– P Phosphorus 31.0		16 2– S Sulphur 32.1		17 – Cl Chlorine 35.5					18 0 Ar Argon 39.9
						32 4+ Ge Germanium 72.6		33 3– As Arsenic 74.9		34 2– Se Selenium 79.0		35 – Br Bromine 79.9					36 0 Kr Krypton 83.8
						50 4+ 2+ Sn Tin 118.7		51 3+ 5+ Sb Antimony 121.8		52 2– Te Tellurium 127.6		53 – I Iodine 126.9					54 0 Xe Xenon 131.3
						82 2+ 4+ Pb Lead 207.2		83 3+ 5+ Bi Bismuth 209.0		84 2+ 4+ Po Polonium (209)		85 – At Astatine (210)					86 0 Rn Radon (222)

- Memorize methane (CH_4)
  ammonia (NH_3)
  water (H_2O)

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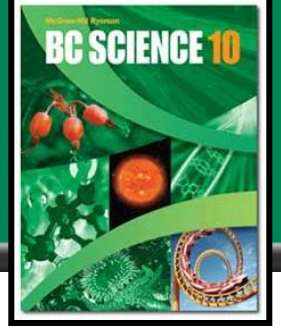
Strategies for Balancing Equations



- **Balance chemical equations by following these steps:**
  - **Trial and error will work but can be very inefficient.**
  - **Balance compounds first and elements last.**
  - **Balance one compound at a time.**
  - **Only add coefficients; NEVER change subscripts.**
  - **If H and O appear in more than one place, attempt to balance them LAST.**
  - **Polyatomic ions (such as SO_4^{2-}) can often be balanced as a whole group.**
  - **Always double-check!!**

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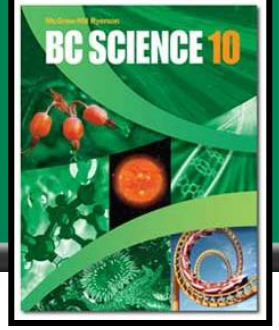
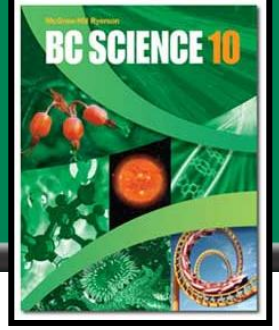


- **Examples:**
  - $Fe + Br_2 \rightarrow FeBr_3$
  - $Sn(NO_2)_4 + K_3PO_4 \rightarrow KNO_2 + Sn_3(PO_4)_4$
  - $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$



- Lithium hydroxide pellets are added to a solution of sulphuric acid, lithium sulphate and water are formed

- Sodium phosphate and calcium chloride react to form calcium phosphate and sodium chloride

- Aluminum bromide and chlorine gas react to form aluminum chloride and bromine gas